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THE HISTORY OF PHYSIOLOGY.

Lectures on the History of Physiology during the Sixteenth, Seventeenth and Eighteenth Centuries. By Sir M. Foster, K.C.B., M.P., M.D., D.C.L., Sec. R.S., Professor of Physiology in the University of Cambridge. Pp. 310. (Cambridge: University Press.)

THERE is no more fascinating chapter in the history of science than that which deals which physiology, but a concise and at the same time compendious account of the early history of the subject has never before been presented to the English reader. Physiologists therefore owe a debt of gratitude to Sir Michael Foster for supplying a want which was widely felt. The following is a short account of the contents of the book, to which no higher praise can be given than to say that it is worthy of the reputation of its author.

As already remarked, the subject itself is a fascinating one, and it is rendered the more so by the manner in which it is treated in these lectures,[1] which abound with interesting biographical details and with quotations from the works of the early masters of science. The work is one which will interest circles far wider than physiological, for so intimately are the natural sciences interconnected that it is impossible to write the history of any one without constantly referring to points in the history of others. This must especially be so with physiology, which is directly based upon anatomy, physics and chemistry. It is not therefore surprising to find that the first lecture is devoted to the work of Vesalius and the early history of anatomy.

Andreas Vesalius was born in Brussels on December 31, 1514; his father was apothecary to the Emperor Charles V., and his mother, "to judge by her maiden name, Isabella Crabbe, was probably of English extraction." He studied at Louvain and at Paris, in the latter place under Jacobus Sylvius and Guinterius. That was a time when neither anatomy nor medicine was recognised outside the pages of Galen: if the facts were not reconcilable with Galen, so much the worse for the facts; it was rank heresy to teach otherwise. But Vesalius early determined to investigate for himself, and, although he had to resort for his material to the graveyard and even to the gibbet, where, he says, "'to the great convenience of the studious, the bodies of those condemned to death were exposed to public view,'" he was not to be deterred from his purpose. At the age of twenty-one he migrated to Venice, and was almost immediately appointed to teach surgery and anatomy at the University of Padua. Here his opportunities for study were far greater than in Paris or Louvain, and after five years' patient labour he produced his great work "On the Structure of the Human Body," which was published at Basel in 1543. "This book," says Foster, "is the beginning, not only of modern anatomy, but of modern physiology."

It is true that Vesalius dealt but little with physiology, being for the most part content to teach the Galenic doctrines, he himself saying that "'he accommodated his statements to the dogmas of Galen, not because he thought that these were in all cases consonant with truth, but because in such a new great work he hesitated to lay down his own opinions, and did not dare to swerve a nail's breadth from the doctrines of the Prince of Medicine.'"

But he no doubt recognised that the new truths about anatomy which he was promulgating involved the modification or rejection of the old dogmas. And it is certain that the publication of his work was so received, for the storm of opposition which it raised from the orthodox teachers of the time proved sufficient to terminate Vesalius' career as an anatomist. In disgust he burnt all his manuscripts, and accepted the post of Court Physician to Charles V. This was in 1544, and, although he lived some twenty years longer and was able to see his work beginning to bear fruit, he himself produced no more.

While it is clear that Vesalius did not really believe that the blood passed from the right heart to the left through the septum, as Galen supposed, it was Servetus, the Unitarian physician who was burnt at the stake by Calvin, who, in a theological work written in 1546 and published in 1553, first clearly enunciated the opinion that the communication occurs through the lungs. But how far this opinion was the result of experiment and observation and how far it was mere conjecture is difficult to say; in any case Servetus' suggestion had little influence upon the progress of physiology, nor was it accepted until, in the course of the following century, the proofs were furnished by Harvey. Like all great discoveries, that of Harvey was led up to by the work of previous observers, more than one of whom arrived very near the truth. This is the case, as we have seen, with Servetus so far as the pulmonary circulation is concerned, with Cæsalpinus, and with Realdus Columbus (who is, however, supposed to have "cribbed" from a manuscript of Servetus). Fabricius of Aquapendente, Harvey's master, supplied in his discovery of the valves of the veins one of the most important facts upon which Harvey's doctrine of the circulation was based. But there can be no difference of opinion as to the fact that the history of physiology itself and all advance in surgery and medicine begins with Harvey, for until the action of the heart and the circulation of the blood were understood there could be no correct understanding of the working of any part of the animal mechanism. To this subject the second lecture is accordingly devoted.

Harvey was born in 1578 at Folkestone. He took his degree at Cambridge in 1597, studied four years under Fabricius at Padua, became physician to St. Bartholomew's Hospital in 1609, and "ventured in 1615 to develope, in his 'Lectures on Anatomy' at the College of Physicians, the view which he was forming concerning the movements of the heart and of the blood. But his book, his *Exercitatio*, did not see the light until 1628." He was physician to Charles I., after whose death "he retired into private life, publishing in 1651 his treatise, *De generatione animalium*, . . . and on June 3, 1667, he ended a life remarkable for its effects rather than for its events."

"His wonderful book, or rather tract, for it is little more, is one sustained and condensed argument." Up

[1] The lectures were delivered as the "Lane Lectures" at the Cooper Medical College in San Francisco in the autumn of 1900.

to the time of Harvey it was supposed, and was commonly taught, that the heart acted like a suction pump, not like a force pump; that the diastole was the active, the systole the passive, condition; that the blood ebbed and flowed in the veins and arteries; that air and vital spirits passed to the heart by the pulmonary arteries; that the blood, or part of the blood, passed from the right ventricle to the left through pores in the septum. Harvey's results were arrived at partly by anatomical observation and inference, but chiefly by physiological observation and experiment. His arguments were founded,

"not on general principles and analogies, but on the results of 'frequent appeals to vivisection.' 'When first I gave my mind to vivisection, as a means of discovering the motions and uses of the heart, and sought to discover these from actual inspection, and not from the writings of others, I found the task so truly arduous, that I was almost tempted to think, with Frascatorius' (a Veronese doctor of the sixteenth century and more a poet than a man of science), 'that the movement of the heart was only to be comprehended by God. For I could neither rightly perceive at first when the systole and when the diastole took place, nor when and where dilatation and contraction occurred, by reason of the rapidity of the movement, which in many animals is accomplished in the twinkling of an eye, coming and going like a flash of lightning.' But the patient and prolonged study of the heart in many animals showed him that 'the motion of the heart consists in a certain universal tension, both of contraction in the line of its fibres and constriction in every sense, that when the heart contracts it is emptied, that the motion which is in general regarded as the diastole of the heart is in truth its systole,' that the active phase of the heart is not that which sucks blood in but that which drives blood out."

In this way Harvey came to see clearly, what had been already dimly guessed at by more than one of his forerunners, that the right heart receives blood from the venæ cavæ and pumps it through the lungs into the left heart. From it there followed

"another conception, which, however, 'was so new, was of so novel and unheard of a character, that in putting it forward he not only feared injury to himself from the enmity of a few, but trembled lest he might have mankind at large for his enemies.' . . . To this new view he was guided by distinctly quantitative considerations. . . . This is what he says: 'I frequently and seriously bethought me, and long revolved in my mind, what might be the quantity of blood which was transmitted, in how short a time its passage might be effected, and the like; and not finding it possible that this could be supplied by the juices of the ingested aliment without the veins on the one hand being drained, and the arteries on the other hand becoming ruptured through the excessive charge of blood, unless the blood should somehow find its way from the arteries into the veins, and so return to the right side of the heart; I began to think whether there might not be *a motion, as it were, in a circle*. Now this I afterwards found to be true. . . .' To that true view of the motion of blood he was led by a series of steps, each in turn based on observations made on the heart as seen in the living animal."

His argument is essentially a physical mechanical argument, and his demonstration was the "deathblow to the doctrine of the distribution of 'animal spirits' by the blood," although he does not himself deal with that doctrine and only refers to it incidentally.

The revival of the study of physics under Galileo and his pupils in the seventeenth century had a marked influence upon the progress of the new physiology, and forms the subject-matter of the third lecture. In particular Borelli (1608–1679), the famous professor of mathematics at Pisa, influenced largely by his friendship with Malpighi, set to work to apply physical laws to physiological problems. His great work, "De motu animalium," was not published until just after his death, but what is printed in it had been taught publicly long before, and much of the work had long been in manuscript.

A large part of Borelli's work is devoted to the special mechanical problems. He treats in succession of muscular mechanics, of standing, walking, running and locomotion in general, and investigates them by the aid of mathematics (his discussions concerning these problems may still be read with profit); he even attempts to solve the nature of muscular motion by mechanical methods. He estimates the force of muscles and of the heart, shows how the elasticity of the arteries aids the flow of blood through them, deals with the mechanics of respiration, and anticipates the modern attempts to account for all the phenomena of secretion by a mechanical explanation. Even nervous phenomena are explained by him as due to oscillations transmitted by a fluid, and in the same spirit he discusses "the generation and nutrition of both plants and animals, and even the nature of several diseases. . . . He was so successful in his mechanical solutions of physiological problems that many coming after him readily rushed to the conclusion that all such problems could be solved by the same methods."

The work of Marcello Malpighi (1628–1694), the friend of Borelli, and his colleague at Pisa during three years, although the greater part of his life was spent at Bologna (his native city), is dealt with at great length in the fourth lecture of the series. With his character the lecturer has obviously the fullest sympathy.

"Kindly even to softness, ready to give his affections to those who seemed drawn to him, devoted wholly to those who had won his love, modest and retiring even to timidity, bold only in the interests of truth and right, never in his own . . . beloved for the sake of himself, even by those who were not competent judges of his talents and his works."

Four years of his life, viz. from 1662–1666, Malpighi spent at Messina, as professor of medicine, and it was here that he began those researches into the minute anatomy of fishes and invertebrates which "opened up in his mind views as to the real nature of the like but more complex structures of man and the higher animals."

Malpighi's relations to the young Royal Society of London are well known. These relations began in 1667 and continued throughout his life, and the Society "had the honour of publishing and of bearing the expense of publication of the greater part of Malpighi's works." His work was essentially founded upon the use of the microscope, which had but recently been invented, or rather improved and rendered an instrument available for research. He and Nehemiah Grew, independently and almost simultaneously, laid the foundations of our knowledge of the structure of plants. He may also be regarded as the founder of embryology, for he gave the

first adequate description of the changes undergone by the developing chick *in ovo*. He described the capillary circulation, and thus completed the immortal discovery of Harvey, and although not the first to observe the corpuscles of the blood, for he was anticipated in this by a few years by Swammerdam, his observation was independent of Swammerdam's, and made long prior to its publication. The extent of his researches into the structure of the tissues and organs is testified to by the number of parts to which his name is attached, *e.g.* the Malpighian tubules of insects, the rete Malpighii of the epidermis, the Malpighian bodies of the spleen and kidney. "Whatever part of natural knowledge he touched he left his mark; he found paths crooked and he left them straight; he found darkness and he left light."

The effect upon physiology of the new knowledge of chemistry which was dawning in the seventeenth century, as the result, in large measure, of the work of van Helmont (1577–1644), mystic though he was in many matters, and of his immediate successors, is dealt with in the fifth and sixth lectures. Practising as a physician, van Helmont was nevertheless mainly occupied, at Vilvorde in Belgium, with carrying out chemical observations and experiments. Although he received the Elijah cloak of Paracelsus, whose spiritualistic doctrines he adopts and even develops, and although he was still imbued with the Galenic doctrines, in spite of the fact that Harvey's work was already published when he wrote and must have been known to him, he nevertheless shows himself to be

"a patient, careful, exact observer . . . who watches, measures and weighs, who takes advantage of the aid of instruments of exact research, who reaches a conclusion by means of accurate quantitative estimations. . . . Throughout the whole of his writings is seen the continued endeavour to weave his exact chemical physical knowledge and his spiritualistic views into a consistent whole. . . . These two sides of van Helmont's character are not unfitly indicated by the two words *gas* and *blas*, 'two new terms,' he himself says, 'introduced by me because a knowledge of them (*i.e.* of the things they indicate) was hidden from the ancients.' By '*blas*' he meant an invisible spiritual agency which directs and governs material changes: this is the *archeus* of Paracelsus. By '*gas*' he clearly meant what we now call carbonic acid gas. . . . He gives it that name because the sound is not so far from that of 'chaos,' the unformed womb of all things."

He shows that gas is produced by the combustion of charcoal, by the fermentation of fruits, by the ignition of gunpowder. He gives an account of digestion, which he likens to fermentation. He recognises the essentially acid nature of the gastric secretion and its chemical action upon food. He describes absorption from the intestines as being due, in part at least, to diffusion. But he does not grasp the idea of the use of air in breathing; he still clings to the old notion of "vital spirits." He anticipates modern physiology in teaching that the tissues prepare their own substance independently from the blood. But, to judge by his writings, van Helmont was at heart more pleased with his blas than with his gas. "He allows to man alone a sensitive soul. The throne of this soul is in the pylorus; 'there it sits and there it abides all life long.' He gives reasons for this conclusion, *e.g.* a great emotion is felt at the pit of the stomach; a severe blow in the pit of the stomach will stop the heart."

Van Helmont was followed by Franciscus Sylvius (1614–1672) in explaining many of the phenomena of the body by the help of chemical science, and by Regner de Graaf (1641–1673) in his observations upon digestion. De Graaf was the first to obtain pancreatic juice, saliva, and bile from artificial fistulæ; his methods are used at the present day. And soon afterwards the knowledge of glands and their functions was still further advanced by the discoveries of Peyer (1653–1712), and von Brunner (1653–1727), of the glands in the intestine now known by their names.

But the progress of chemical science was destined to be arrested for many years by the speculations and teaching of George Ernest Stahl (1660–1734), who was successively court physician at Weimar, professor of medicine at Halle, and physician to the King of Prussia. "He was an accomplished chemist, and his name must always be borne in mind in dealing with the history of science, if for nothing else, for the reason that he was the author of the famous theory of phlogiston, which ruled with a rod of iron, as it were, the thoughts of natural philosophers for a hundred years."

Stahl maintained the view that the chemical changes of the living body were entirely different from those of the laboratory, that they were directly governed by the sensitive soul, which pervaded all parts, which not only set the chemical agent in motion, but was itself the agent. "He thus stands forth at the close of the seventeenth century as the founder of 'animism,'" a doctrine which, under the name of a vital principle, maintained itself through the succeeding centuries, and exists in a modified form even at the present day.

The seventh lecture of the series, which is devoted to the English school of the seventeenth century and deals mainly with the evolution of the physiology of respiration, is one of great interest, bound up as it is with the early history of the Royal Society. The fundamental experiment that a candle goes out, an animal dies, in a space deprived of air is due to Robert Boyle (1660). Robert Hook in 1667 showed the Fellows of the Royal Society that an animal can be kept alive by artificial respiration without any movement of the lung or chest wall; that the air alone, coming in contact with the blood, is the essential part of respiration. Richard Lower (1631–1690), besides his well-known work on transfusion and on the structure and action of the heart, also carried the subject of the physiology of respiration still further by showing that the change of the blood from venous to arterial is merely a change of colour due to air; he concluded that this entrance of fresh air into the blood is as necessary for the body as for the combustion of fuel. But it was left for John Mayow (1643–1679) to prove that it is a part only of the air to which this property is due, and to this part he gave the name of "nitro-aereal or igneo-aereal" spirit, which was neither more nor less than that which we now term oxygen. This was before Stahl had introduced the phlogiston theory, the essence of which was that when a combustible body was burned, phlogiston departed from it: it lost weight. Mayow is quite explicit on this point, showing that when antimonium is

burned it increases considerably in weight. "'Now we can hardly conceive that the increase of weight of the antimonium arises from anything else than from the igneo-aereal particles inserted into it during the calcination.'"

Mayow fully identified burning and breathing. He found that either a lighted candle or an animal in an enclosed space exhausts a certain proportion of the air. "'We may infer,'" he says, "'that animals and fire deprive the air of particles of the same kind.'" "'It is clear,'" he adds elsewhere, "'that even the very plants seem to have some need of breathing, some need of drawing air into themselves.'" "In his tract, 'On Respiration,' he gives an exposition of the mechanics of breathing which might almost find its place in a text-book of the present day." He further supposed that the heat of the body is kept up by union of tiny nitro-aereal particles with salino-sulphureous (*i.e.* combustible) particles of the blood—a "sound theory," says Foster, "of animal heat," although now superseded, as will be subsequently seen, by one which places the union in the tissues themselves.

But the "great truth" which had been reached by the labours of these English physicists and physiologists died out with Mayow.

"The world had to wait for more than a hundred years till Mayow's thought arose again, as it were, from the grave in a new dress, and with a new name; and that which in the first years of the latter half of the seventeenth century as igneo-aereal particles shone out in a flash and then died away again in darkness, in the last years of the eighteenth century, as oxygen, lit a light which has burned, and which has lighted the world with increasing steadiness up to the present day."

The rise of the modern doctrines of combustion and respiration, the work of Black, Priestley and Lavoisier, is dealt with in the ninth lecture of the series, the eighth being devoted to the researches of Réaumur, Spallanzani, Stevens and John Hunter on gastric digestion. Although van Helmont had shown the stomach to be a great digestive organ and the acid character of its secretion its essential feature, subsequent authorities had ignored or denied its agency in digestion. It was regarded as having mainly a mechanical function. But Réaumur, who was eminent in other sciences besides physiology, showed clearly, by causing a kite to swallow small metal tubes closed at each end by a grating and filled with food, that without any trituration and with no semblance of putrefaction both meat and bone became dissolved whereas vegetable grains were little altered. He even obtained gastric juice from pieces of sponge included in the tubes, and found it to be acid. Spallanzani, who was born in 1729 and the centenary of whose death was celebrated two years ago, was successively professor of logic at Reggio and of natural history at Modena and at Pavia. He wrote on many subjects of natural history, but in physiology chiefly upon respiration and digestion—experimenting by Réaumur's methods upon all kinds of animals and even upon himself. He obtained gastric juice as Réaumur had done, but was successful in showing its activity *in vitro*, in which Réaumur had not succeeded; he failed, however, to detect its acid character. Similar experiments to those of Spallanzani were made independently by Stevens, of Edinburgh, who announced his results in an inaugural thesis in 1777, the same year as the publication of Spallanzani's first paper on the subject. Stevens also obtained "pure gastric fluid" from the stomach of a dog killed during fasting, and found that at the body temperature it readily dissolved meat, and he made besides numerous experiments by Réaumur's method on digestion *in vivo*. John Hunter, in 1772, "constantly found that there was an acid, though not a strong one," in the gastric juice, but later on he is led to regard this as not essential. The acidity which van Helmont had insisted upon at the beginning of the seventeenth century was not accepted until the nineteenth.

Stephen Hales (1677–1761) was a Fellow of Corpus Christi College, Cambridge, and became perpetual curate of Teddington in Middlesex. "He was devoted to science; he had begun to experiment while at Cambridge in the 'elaboratory' of Trinity College," where Bentley was then master; "and he continued his researches amid his parish duties at Teddington." He was the first to determine by experiment upon the living animal (horse) the pressure of the blood in the arteries, and he dealt also with the flow of sap in plants. "His writings contain the first clear enunciation of the existence of gases in a free and in a combined condition."

It is the merit of Joseph Black (1728–1799), who was professor of chemistry successively in Glasgow and Edinburgh, to have rediscovered the "gas" of van Helmont: to this he gave the name of "fixed air." He proved that it is given off in combustion, in fermentation and in respiration; that it is irrespirable; and he at first thought that it formed the irrespirable portion of the atmosphere. But Rutherford, of Edinburgh, in his inaugural thesis in 1772, showed that after the "fixed air" (caused by combustion) had been removed by caustic alkali, "a very large proportion of air remains which extinguishes life and flame in an instant." This was nothing else than the discovery of *nitrogen*, although its connection with nitre was first shown later by Cavendish.

Just as Black rediscovered the *gas sylvestre* of van Helmont, so Priestley (1733–1804) and Lavoisier (1743–1794) rediscovered the gas which Mayow had termed the igneo-aereal spirit and which was ultimately named by Lavoisier *oxygen*. Priestley was a Unitarian minister—"a man of letters as well as man of science, prolific theologian and ardent politician." He was the first to discover that the something in the air which is removed by the burning of a candle or by the respiration of an animal is restored by vegetation. He obtained from mercuric oxide (*mercurius calcinatus per se*), by heating it with a burning glass, a quantity of "air." "'Having got about three or four times as much as the bulk of my materials, I admitted water to it, and found that it was not imbibed by it. But what surprised me more than I can well express was that a candle burned in this air with a remarkably vigorous flame . . . and a piece of red-hot wood sparkled in it.'"

"He obtained the same gas from red precipitate and from minium; he found that a mouse lived well in it . . . that it was four or five times as good as common air."

Imbued with the phlogistic theory, he regarded it as common air which was freed from phlogiston, "dephlo-

gisticated air," and he endeavoured to explain all his own results as well as the changes occurring in combustion and respiration on the same theory. Thus although in 1774 he prepared oxygen he did not discover it in the true sense of the word, because he failed to understand his discovery. This was reserved for Lavoisier, who, in the year following (1775), published his paper "On the nature of the principle which combines with metals during their calcination," in which he conclusively showed that the principle is taken up from the air, is part of the air. Two years later he demonstrated that the same substance "is the constructive principle of acidity," and he called it the acidifying (or oxygine) principle.

The composition of the atmosphere now became clear; the discovery, or rediscovery, of nitrogen (or *azote*, from its inability to support life) naturally followed, and the gaseous exchanges in the lungs between oxygen from the air and Black's "fixed air," or "aeriform calcic acid," as it was at first termed by Lavoisier, were demonstrated, as we at present understand them. "Thus at a single stroke did this clear-sighted inquirer solve the problem of oxidation, and almost, if not quite, the problem of respiration." This was in 1777.

Three years later Lavoisier and Laplace published their celebrated memoir on heat. In this they definitely state—as the result of measurements of the amount of heat produced by the combustion of a given weight of carbon when burned to carbonic acid, and the amount given out by an animal with the production of a given quantity of carbonic acid—that "respiration is a combustion, slow it is true, but otherwise perfectly similar to the combustion of charcoal. It takes place in the interior of the lung . . . The heat developed by this combustion is communicated to the blood . . . and is distributed over the whole animal system." Later Lavoisier recognised that the combustion of hydrogen, which had been discovered by Cavendish in 1781, takes a part in the production of animal heat. Not until long after Lavoisier—not, in fact, until well into the nineteenth century—was it recognised that the combination of oxygen with carbon and hydrogen occurs, not in the lungs, but in the tissues. Lavoisier was but fifty years old when he was swept away, in 1794, in the maelstrom of the Revolution; all too soon for the science which he had done so much, and in so short a time, to advance.

The tenth and final lecture is devoted to the older doctrines of the nervous system. The views of Vesalius and of Descartes (1596–1650), of Willis (1621–1675) and Glisson (1597–1677), of Borelli, of Stensen (1638–1686) and of Haller (1708–1777) are here set forth, and the history of the doctrine of "irritability" of tissues, first enunciated by Glisson and afterwards by Haller, is described. But, as a matter of fact, the physiology of the nervous system is almost entirely the product of the nineteenth century; before that it can scarcely be said to have a history; everything was obscure, and the place of facts was occupied for the most part by vague speculations.

One of the most prolific subjects of such speculation was the seat of the soul, which was assigned by van Helmont (as we have already seen) to the pit of the stomach, by Descartes to the pineal gland, by Haller, with better reason, to the medulla oblongata. "But we have learned much since Haller's time." . . . "And if he," adds Foster, "with the knowledge and the means at his command, seems to us to-day to have often gone astray, shall not we ourselves one hundred years hence still more often appear to have gone astray?" To which it may perhaps be replied that, although it will always be human to err, yet the means at our command are so much more complete and the methods so much more accurate that it is far less likely that we shall take a start in a wrong direction, or, having taken it, shall continue in it; in this at least we have an advantage over our eighteenth century predecessors, whose methods were, comparatively speaking, rough and their means and opportunities relatively limited.

Whilst endeavouring in the above account to give a general idea of the character of the book with which Sir Michael Foster has enriched the world of science, it is by no means an easy task to do adequate justice to the mine of literary and historic research which the author has laid open to view. But if a perusal of this account serves to induce others to go to the original, we can promise them that they will find it as interesting a story as may be met with for many a long day. And it is to be hoped that the perusal of Sir Michael Foster's history will stimulate the desire of its readers to make the direct acquaintance of the great authors who, during the three centuries under review, laid the foundations of modern physiology and, with it, of the sciences upon which modern physiology is based.

E. A. S.

FILTRATION OF WATER.

Water Filtration Works. By James H. Fuertes. Pp. xviii + 283. (New York: John Wiley and Sons; London: Chapman and Hall, Ltd., 1901.) Price 10*s.* 6*d.*

FILTRATION, which is generally regarded as an essential process in the provision of domestic water-supplies for large towns in England, especially when rivers constitute the source of supply, has been neglected to a considerable extent in the United States, and, therefore, the publication of a book, by an American engineer, dealing wholly with this subject, will be particularly valuable if it should lead municipalities in the United States to the more general adoption of this safeguard against the distribution of water to large populations in a condition dangerous to health. Polluted river waters, in their natural condition, have proved very fatal to our troops in South Africa, as shown by the high rate of mortality from enteric or typhoid fever; and the author, at the commencement of his book, draws a very striking contrast between the annual death-rate from typhoid fever per 100,000 persons in cities supplied with pure or filtered water, such as the Hague, Munich, Dresden, and Berlin, with a typhoid death-rate of only from 4·7 to 7, and Washington, Louisville, and Pittsburg, supplied with unfiltered river water, where the yearly typhoid death-rate for several years has averaged 71, 74, and 84, respectively, per hundred thousand of population. River waters are to some extent purified by natural agencies during their downward flow if no fresh causes of contamination are introduced, depending on